AN OVERVIEW OF THE RECORDING TECHNIQUES AND EQUIPMENT FOR POST PRODUCTION

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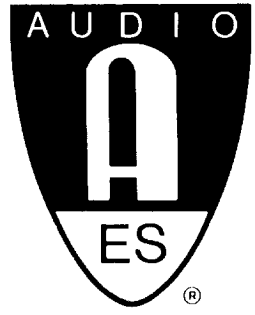

AN OVERVIEW OF THE RECORDING TECHNIQUES AND EQUIPMENT FOR POST PRODUCTION

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Summary

Once one takes the step to a separate audio recorder, time-code locked to the video recorder, production flexibility is limited only by one's imagination. This paper will review those features of today's audio recorders which are of significance to television production. Included in the paper is a discussion of advantages such as audio signal quality, audio material handling techniques, and cost-time savings, as well as limitations that must be considered in operation of the audio recorder.

INTRODUCTION

One or two narrow audio tracks near the edge of a two inch wide video tape provide very limited technical flexibility in the sound portion of a television production. On the other hand, when one takes the step to using a separate audio recorder (or recorders) which is "time code locked" to the video recorder, the production flexibility is limited only by ones imagination. This paper is a review of those features of today's professional audio recorders which are significant in this double system approach to television recording.

There are two basic schemes for implementation of time code control systems. The first and most sophisticated concept is to slave all video and audio machines to a central source of time code control. Examples of this type include the CMX system and the EDM-1 marketed by Ampex. These systems provide an operator control station where the status of each machine and its program are displayed. From here, the operator can develop, rehearse and implement a large repertoire of video and audio edits complete with special effects.

The second concept, which is more convenient and is simpler for small operations, is to delagate one machine to be the master and the other machines the slaves. This

so called "chase" feature is available on the EECO systems of which their model MQS-100 is the latest available. In the "chase" mode, one may operate the video recorder in the normal manner and the audio machine will simply follow it. This is accomplished in the MQS-100 by the microprocessor based controller which senses the time code positions and operating modes of both machines. When the master is put into the play or record modes the slave is automatically started and held in frame-for-frame synchronization through control of its capstan motor speed. In standby, hand cueing or fastwind modes, the controller senses the difference between machine locations. When the slave machine is found to be more than ten frames away from the master, the slave is driven back into synchronism via its fastwind controls.

With the aid of either one of these control systems and the appropriate complement of video and audio recorders, an audio mixing console, and special effects devices, one will be able to create the desired audio visual impact. The record industry has been responsible for development of an arsenal of creative audio production tools which the television producer can also choose from.

What special features of today's tape recorders should one understand in planning and using a multiple recorder system?

BETTER AUDIO SIGNAL QUALITY

Signal to Noise Ratio, Distortion, Frequency Response, and Flutter are the terms used to identify the causes of audible sound quality reduction in the recording process. In tape recorders, these parameters are controlled by a complex combination of electrical and mechanical design considerations. In video recorders, the design is optomized for best picture quality some times at the cost of sound quality, while in audio recorders, sound quality is king.

The first detractor to audio signal-to-noise ratio on a quad VTR system is the transverse orientation of the oxide particles on the tape. This orientation is optimal for video, but for a longitudinal recording, it causes a drop of 6-10 dB in the maximum output capability before distortion. Unfortunately the tape noise does not follow suit so consequently the dynamic range and signal-to-noise ratio are reduced by some 6-10 dB below the value which could be obtained using the same oxide longitudinally oriented.

This orientation problem does not occur on helical video tapes, but the narrower tracks and thinner oxide used on some helical machines today do detract from signal-to-noise ratio.

Quad video tape has somewhat thinner oxide than good audio tape also. Then the presence of the video signal in the same chassis with audio signal will almost inevitably introduce interference in the sound. The final result is a 56 dB S/N spec on a Quad VTR vs 64 and 69 dB on current 16 track and 4 track Audio Recorders.

The new audio tapes designed specifically for master recording have improved particle orientation which significantly reduces third harmonic distortion and intermodulation distortion. These tapes also have greater headroom on the high end allowing 3 dB higher recording levels than was practicle just a few years ago and 6 dB higher than a decade ago.

Another drawback in quad VTRs is that the rotary video heads contacting the tape at a 960 Hz rate (in 60 Hz power line environments), produces some velocity variations in the longitudinal tape motion. This results in frequency modulation of any audio signal which may be present.

If an audio recording is reproduced on the same VTR, then the modulation is effectively cancelled. However, if the tape path geometry changes for any reason, for example, in interchange from one transport to another, then the cancellation may not be exact and the modulation sidebands may become evident.

This mechanism alone degrades the audio quality. Unfortunately the phenomenon is not disclosed by normal flutter measurements, it is in fact not perceived as flutter, but

rather as a "blurring" of the signal.

Over several generations, the modulation sidebands will themselves cause additional intermodulation products, and the final result may become objectionable.

The gap chosen for the combined record/playback head on a VTR is, of necessity, a compromise between the requirement for a short gap to minimize gap loss in reproducing, and the longer gap required to optimize the record process. This problem becomes more acute at slower tapes speeds, since the wave length on tape become shorter for a given frequency and the head gap length dictate the minimum wave length it can reproduce.

The optimum recording gap length, on the other hand, is generally dependent upon the oxide thickness, shortest wavelength to be recorded, and on the spread in oxide particle switching fields. In general , for a given oxide type and coating thickness, the shorter the record gap, the more high frequency preemphasis will be required during recording.

Audio Recorders usually have separate record and playback heads each optomized for their function. The exceptions are the high speed multitrack machines where, at 30 ips, the playback head gap can be as long as the record head gap. This allows equal playback quality from both heads.

CREATIVITY IN AUDIO MATERIAL HANDLING

The first creative tool to consider, the multichannel mixing console, is probably the most accepted in broadcast television.

Here the flexibility afforded by having twenty, thirty or more inputs has it's biggest impact in live television shows. For example, the ability to close mike the orchestra permits good control of aural balance in what otherwise might be a very infavorable acoustic environment. The ability to preset groups of microphones for each set relieves the need to frantically repatch and re-balance for the next shot.

In the recording industry the sophistication of these consoles has grown to the point where a record made from a recording done at a live concert, is difficult to distinguish, from a technical standpoint, from one made under the normally ideal conditions of a recording studio.

A consequence of this is that the major recording artists making a tv show, need not fear that their particular "sound" which may well have been largely created in the recording studio, can not be very closely emulated in a live performance in front of tv cameras.

In addition, an artist may even bring his favorite mixing engineer to the tv studio to ensure similarity of his "sound" to that on released discs and tapes.

In this event the visiting engineer would feel more at home today than ever before in front of the mixing console in the tv studio, since it will be very similar to the console in the recording studio.

Probably the greatest impact which sophisticated mixing consoles give to the production house, is the ability to control the minutest segment of the audio and to be able to produce a far better and more appropriate sound. Because of this, the physical siting of an artist and musicians (for example) on the studio floor, becomes much more flexibile, permitting a greater freedom for the producer, with less likelihood of . undesired extraneous pick up.

The advent of lightweight high performance hyper cardiod or "shotgun" type microphones has played a significant part in keeping microphones off camera in wide angle shots. In the same vein, the greatly improved quality and reliability of radio microphones has also contributed to improved flexibility. These two improvements owe their origin to the demands of live stage and tv production.

The multi-track audio recorder, coupled with a multichannel mixer provides one the kind of creative control of audio in post production that an orchestra conductor has in the concert hall. He influences each instrument individually, and through repeated rehearsels, is able to shape them into a pleasing unified sound.

The record industry has developed the creative flexibility of multichannel recording into a fine art. With the aid of multiple tone controls, reverb chambers, digital delay lines and even synthesizers, the final product sometimes bears little similarity to that which the musicians originally played. For example the technique of "Overdubbing" in combination with these devices can transform a handfull of artists from a small studio into a grand orchestra and chorus with the live sound of a giant concert hall.

Overdubbing consists of using the record head in a reproducing mode for those tracks already recorded. Ampex calls this the Sel Sync*system. The output of these tracks is appropriately mixed and fed to the artist or artists through earphones. When adding a vocal to a background for example, the vocalist sings in time with the earphone signal, while his singing is being recorded in a separate track, in spacial synchronism on the tape with the backing material already recorded. This technique permits multiple attempts at any single track without changing any other track, and without requiring any generation build up on other tracks as would be the case with the old sound-on-sound technique.

Some of you may remember back in the mid fifty's when Les Paul and Mary Ford introduced a new sound on records where he played and recorded his guitar some 20 times.

* TM, Ampex Corp.

He then added a chorus made by having his wife Mary sing all the parts, one at a time, of course. Les Paul was a pioneer in using this sync technique and is still active in the industry with studios in his New Jersey home.

Another,and possibly more significant, use of the multi-track technology is in the ability to build up any conventional program one step at a time. Using the video image as reference, the performer, announcer, background music, sound effects, laughs and applause may each be layed down one at a time in proper time synchronization but on its own track. More than one track may be used for background music, or other material if overlapping elements are needed Now the producer can rehearse and readjust balance as many times as he wishes before finally committing to a mix.

It is important to note, as mentioned earlier, that sync playback quality on a good multitrack machine is equal to normal playback head quality so it is practical to "Ping Pong" material from one track to another in synchronism. This even allows one to do the mix-down in steps. For example, one may wish to get all the music and voices combined onto one track and then mix in the laugh or applause at a later time.

Multichannel recorders have been on the market for many years, but the uninitiated individual may be confused by the variety of configurations available. At the time when the industry first moved from using the full width of a 1/4 inch

tape for recording one monaural program to putting on two programs side by side, a track width of about 70 mils was chosen. The remaining 100 or so mils were designated as guard bands or unused areas between tracks and at the outside edges of the tape to minimize cross talk and tape width variation effects. This concept was expanded to 4 tracks on half inch, then 8 tracks on one inch tape and eventually 16 tracks on 2 inch tape. The first such 2 inch audio recorders utilized a quad video transport with stationary audio head stack in place of the rotating video head assembly. Just as earlier improvements in tape quality eventually brought the 70 mil trackwidth performance up to that of the original full track systems, recent advances in tape have allowed us to crowd 24 tracks of 43 mil width onto a 2 inch tape. Currently the 16 and 24 track machines are enjoying about equal popularity in new machine sales.

Once one has a 2 inch audio transport in house, he is quite flexible in choice of formats. By simply exchanging the plug in head assemblies and guides, one can handle 1 inch - 8 track, 2 inch - 16 track and 2 inch-24 track tapes. If the machine was originally purchased with only 8 or 16 channels of signal electronics, additional bays can be purchased and simply plugged in.

A special head assembly is also available for the Ampex 2 inch audio recorder which has the longitudinal audio track

configuration of a Quad video machine. This Ampex video lay-back head assembly mates with the MM-1100 and MM-1200 mastering recorders. In addition to the normally expected erase and record/playback heads, there is a separate, narrow gap playback head for both audio and cue tracks. This permits reproducing a previously recorded audio track with a better frequency response and signal to noise ratio than a normal audio record/playback head on a VTR, as well as confidence monitoring during a recording. If therefore this assembly is used for the initial transfer from quad tape to audio machine prior to sweetening, the transfer can be made away from the relatively hostile audio environment of a quad VTR. This process will result in less degradation in the final signal.

Another recent addition to audio machines is Audio Insert Editing. This requires the provisions of a suitable delay between the erase and record/bias signals on a magnetic recorder. This delay prevents overlapping recordings when entering record and a gap when exiting record, when making an audio insert edit into a previously recorded track.

This feature, already provided on the Ampex ATR-100 and AVR1,2&3 can now be added as an accessory, (PURC bias and erase card), to any or all channels on Ampex AG-440's, MM-1100's and MM-1200's.

This is a case where the special requirements of the broadcast television and film industry, have stimulated an addition to the capabilities of conventional audio recorders. The

feature also has application in the audio mastering industry but is most suited on applications where it will be under automatic control.

COST AND TIME SAVINGS

The concept of using a helical "work print" tape of the video program for the audio sweetening process is exciting because the master video tape is not subject to damage. The cost savings in the reduced wear and tear on this master tape is hard to measure. This concept also leaves the expensive quad recorder available for new production work while the time consuming audio work is being done.

By using multi-track audio, time and cost can be saved in many ways. Imagine what would happen if the words to a song had to be changed. With a multi-track audio master tape available, it is only necessary to re-record the vocalist, and not the whole orchestra. If one should get a sour musician in the group, redo just his track, after the others have gone home. One could even go so far as to mail the tape from Hollywood to Manhattan to add a track rather than have the expensive artist fly to Hollywood.

Assemble edits, or "Punch-ins", can save a lot of time in a live recording session. For example, if a recording were good except for the last few measures, it is not necessary to redo from the beginning. Simply go back a short distance before the bad spot and have the performer play again in sync with the first take which he follows via headphones. Then at an appropriate point prior to the bad spot, switch into the record mode. The record head which was playing back will start recording again and the earphone feed will be switched to input monitoring for a smooth transition.

INTERFACING WITH AUTOMATIC OR COMPUTER CONTROLS

All motion functions in today's audio and video recorders are actuated by a motor, solenoid or some other electro-mechanical transducer. The simple functions such as PLAY, STOP, etc. are initiated by a simple "ground true" circuit closure. Those that are not TTL inputs can at least be driven by open collector, high voltage TTL outputs. Open collector drivers must always be used to allow for "wired-OR" operation with the manual pushbuttons and other possible control systems.

Electronic reel motor servos have become common place as the most practical way to keep the tape tension constant on the wide range of tape pack radii and tape widths useable on a given transport. Once the step is taken to controlling the motor torque electronically, it becomes relatively easy to add nice features such as the variable fastwind speed control or "Joy Stick". More significantly, the fastwind tape motion can be easily handled by an outside controller by alternately actuating the Fast Forward and Rewind functions at a high rate, the tape speed in a given direction being proportional to the relative time spent in that mode. Most cueing systems use this method today because of the ease of interfacing through the machines remote control connector.

Servo controlled, direct drive capstan motors are available, if not standard, in all the modern audio transports. Access to the input port of the capstan servo is usually made available externally for a variety of accessories. The simplest of these is probably the variable pitch control accessory which may also give selectable speed increments in either 1/4 tone, % of nominal, or absolute speed steps.

The capstan speed control signal may be a dc voltage, but more likely it is a square wave or pulse drive. Most capstan servos are the phase-lock-loop type because crystal oscillator reference is the best way to get good stability. For external speed control, one simply breaks into the crystal clock line and substitutes a TTL compatible square wave, who's frequency determines the capstan velocity.

Tape lifters are also solenoid controlled so one can defeat them in fastwind. This is important to allow "time code" reading in fastwind automated cueing modes. One bad side effect of this is that all of the sound channels will chatter too, so muting must be provided externally. The other potentially bad side effect is the shortening of head life.

The newest features available to aid computer control of an audio machine are found in the AMPEX ATR-100. In this machine, the tape is under continuous capstan control

at all speeds and there is no pinchroller to contend with in play mode. Its quick, smooth tape motion, without fear of tape damage, makes this machine a pleasure to work with. Also available on this machine is remote controllable signal switching for each channel.

SOME RECORDER LIMITATIONS MUST BE ACCOMODATED

There are several limitations in audio recorders which should be understood before working with a synchronizing system.

It is often impossible to "ping-pong" to an adjacent track (ie re-record in the sync mode from one track to the next) due to the close proximity of adjacent heads in a headstack. Sometimes enough of the high level record signal is transformer coupled into the adjacent head to cause feedback oscillation similar to having the gain too high on the PA microphone. With proper advance planning of track assignments one can get around this problem.

The nature of time code is such that crosstalk into the adjacent channel is a problem on some machines. Keeping the code amplitude low will sometimes be an adequate solution. A positive solution is to put the code on an edge track and then leave the next unused or use it just as a scratch pad track.

If two music tracks are to be mixed from separate time-code-synchronized audio recorders, these tracks must not have identical material on them. The reason is that the phasing between machines is not accurate enough and one will hear strange signal summing and canceling effects similar to "flanging". This problem can be avoided by making advance track assignments so that any two mic. channels recorded at the same time will be put on the same machine if they are going to be mixed eventually.

The 2" audio tape transport may be slower spooling than the video transport in a system using the quad recorder. On the other hand, the low cost helical machine used for the off line editing may be the slowest transport. In any event, the speed difference must be accomodated. There are problems with reading time code in fastwind on audio recorders because the normal audio band width of the electronics is inadequate. A bandwidth in the order of 150 KHz is needed. This means either an adjustment to the reproduce equalization or a special wideband preamp is needed.

Limited bandwidth in the electronics or limited reading speed capability of the time code reader can be accomodated in an automated system. The maximum tape speed can be limited by the transport controller simply pulsing the opposing direction line for short periods whenever the tape velocity is sensed and found to be above the desired threshold.

In Conclusion

While production flexibility and cost savings might be the primary reasons for considering a double system facility, the technical quality of the sound is important to today's sophisticated audience. Witness the size of the consumer H.F. business. Even the intelligibility of speech is dependent on careful control of the audio channel. And while video might be taken 4 or 5 generations from the original with very little degradation, 4 generations through a quad VTR audio channel will reduce the signal to noise ratio by at least 6 dB for random noise, and by 12 dB for any coherent residual signals such as video sync rates and power line components.

As a closing thought, consider this. If the quality of the transmitted sound is excellent, the receiver manufacturer who responds to this may find a positive response to his product also.

I would like to thank Alastair Heaslett, my associate at Ampex, for sharing material for this paper from works of his on the same subject.

DIAGRAMS ON 2X2 SLIDES

1 - First transfer - video and dialog to Helical and Audio machines.

2 - Alternate method - recording directly onto Audio and Helical machines during initial live production.

3 - Adding audio sweetening while monitoring video playback from Helical machine.

4 - Final audio mix and transfer to a separate audio machine.

5 - Final release mix directly onto quad VTR and possible second audio copy.

6 - VTR - AVR-3

"Smart Machine" has simple time code cueing and editing system built in.

7 - Helical VTR - VRP-1

Small and less expensive, has slow-motion and still frame capability.

8 - Helical VPR-1 in production console

Has digital time base corrector for broadcast quality video.

9 - Multichannel Audio Mixer

10 - 2-Channel 1/4 inch or 4 channel 1/2 inch Audio Recorder-ATR-100

Fully remote controllable - no pinchroller

11 - 8-Channel - 1 inch or 16 & 24 channel - 2 inch Multitrack Audio Recorder - MM-1200

Overhead Bridge contains EECO equipment

12 - EECO Multi-Cue Synchronizer MQS-100

Will synchronize one VTR or two ATR's

13 - Computer Controlled Editing System - EDM-1

14 - 24-Track Head Assembly for 2 inch tape

15 - Video Layback head assembly for 2 inch audio machine.